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Summary of Contents

The cover photograph shows the upper part of the Austrian antenna tower on the Mugl near Bruck/Mur.

The arrangement of the dipole arrays of Rohde & Schwarz for VHF Broadcasting Band II and TV Band III gives the special directional pattern of this transmitting antenna.

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UHF Test Receivers

Every laboratory must have a number of typical instruments in order to solve the measurement problems on hand. The UHF laboratory essentially requires the following standard instruments: signal generators, slotted and non-slotted lines, power meters, terminating resistors, attenuator pads and voltmeters. An exact direct measurement of small currents being almost impossible with high frequencies, it is generally reduced to a voltage measurement, so that voltage-measuring instruments are especially important for the UHF laboratory. The type of instrument used for these measurements is the test receiver.

A characteristic feature in UHF measurements is the great level difference often encountered. The available power to be measured is often so low that it can be detected only with very sensitive superheterodyne receivers. For a long time, only simple diodes were available for this purpose, the rectified modulation voltage of which was boosted by an AF amplifier and then indicated. This simple solution is unsatisfactory because, due to the square-law sensitivity drop in the rectifier, a very high AF amplification is required for indicating a lowest carrier voltage of about 1 mv. With these degrees of amplification, however, it is dubious whether the setup is stable and can be calibrated.

Superheterodyning permits the voltage sensitivity to be increased by about 3 orders of magnitude. The disadvantages of lack of stability are avoided. Linear indication is ensured from several microvolts up to about 50 mv.

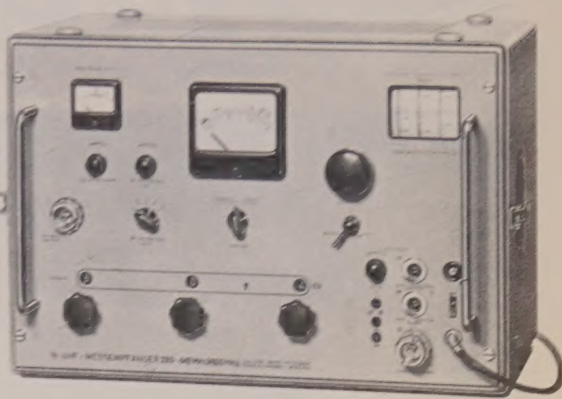
Today most superheterodyne receivers are so reliable that they meet the requirements of the laboratory engineer in any respect. This, of course, is reached only with an elaborate design.

Examples of Measurements:

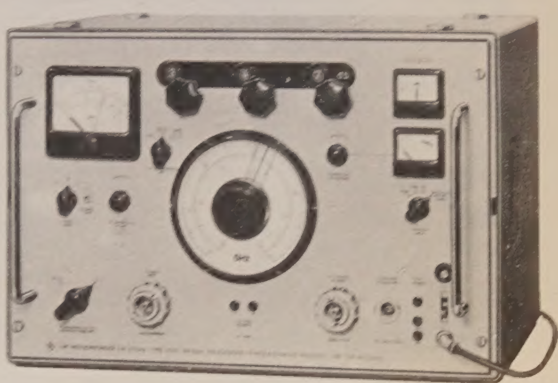
1. Measuring the Reflection with the Reflectometer

The simplest way to measure the reflection of lines or terminations is to use the reflectometer. It has 2 probes, one of which picks up a voltage proportional to the incident wave, while the other picks up a voltage proportional to the reflected wave. The value of the reflection coefficient then is the ratio between the two measured voltages.

$$|r| = \frac{E_r}{E_i}$$



UHF Test Receiver Type USVD



UHF Test Receiver Type USVU

Reflectometers can be very accurate if the power picked up is low in relation to the incident power. Generally, the coupling attenuation is 20 to 30 db. The picked-up amplitude of the reflected wave depends on the magnitude of the reflection. The reflection coefficient thus is the ratio of the amplitude at the probe picking up the reflected wave to the amplitude picked up by the probe for the incident wave. A reflection coefficient of r = 1 % means that the reflected wave is 40 db smaller than the incident wave. Together with the above-mentioned coupling attenuation of from 20 to 30 db, total level differences of from 60 to 70 db must be envisaged when measuring reflections of 1 %. If the reflectometer is fed with 1 v, the available test voltage for this case is lower than 1 mv. It is obvious that these voltages can be measured with sufficient accuracy only by means of the superheterodyne receiver.

Fig. 1a shows the **reflection measurement** on a lossy line for Bands IV and V. With long lines, the reflection is largely dependent on the frequency. The test points, therefore, must be very

close to one another (Fig. 1b). Use of the reflectometer simplifies the work considerably. The advantage of the rugged Dezifix connectors becomes obvious during the measurement, since the reflectometer can be directly connected to the lossy line without any further support. Connecting cables which are often likely to cause errors at the connecting points are thus eliminated. The reflectometer is provided with a switch by means of which the receiver can be connected either to the probe for the incident wave or to that for the reflected wave. If the test receiver has a calibrated gain control in the form of an attenuation box with db indication, it is simple to form the quotient of the two voltages. First measure the reflected voltage and mark the deflection on the scale of the meter. Then switch over to INCID. WAVE and reduce the gain until the same meter deflection occurs. The voltage ratio, which is also called return loss a, is read in db at the attenuation box. The relation between return loss a (in db), the **reflection coefficient** r, the inverse VSWR m and the VSWR s may be seen from the table at the end of this article. Although one and the same phenomenon is involved, i. e. the reflection, 4 technical terms are commonly used nowadays. This is due to the different measuring instruments which can be used for measuring the reflection. The term **return loss** has come from the conception that the reflected wave flows back from the termination and is attenuated by a certain ratio (db) as compared to the incident wave. If a slotted line is used for the measurement instead of the reflectometer, the reflection manifests itself as a standing wave

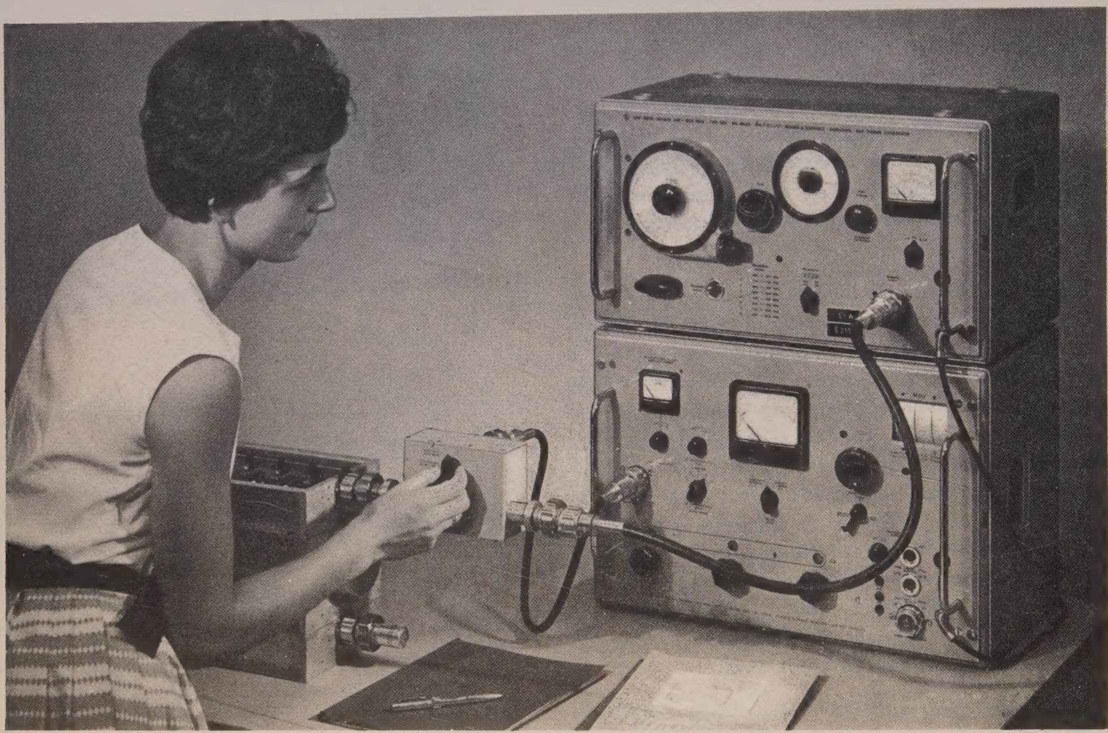


Fig. 1a Measuring the reflection at a lossy line for the TV Bands IV und V, using the reflectometer

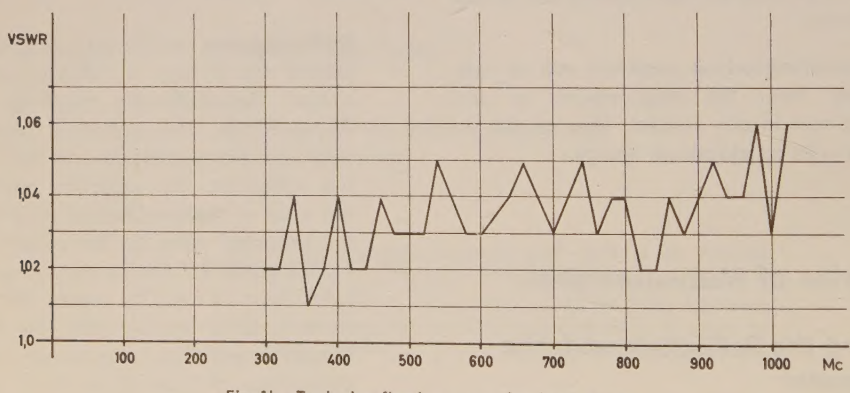


Fig. 1b Typical reflection curve for long lines

which causes an unequal voltage distribution on the slotted line. The quotient from the highest voltage E_{max} and the lowest voltage E_{min} is the **VSWR** $s = E_{max}/E_{min}$. The ratio E_{min}/E_{max} with the symbol m is termed **inverse VSWR.**

2. Measuring the Attenuation

Attenuation measurements are generally made with attenuation boxes. If the attenuation is not too high, a test receiver with a calibrated gain control can be used for this purpose. As already mentioned at the beginning, the IF in superheterodyning is a linear function of the input voltage, provided it does not exceed 50 mv. Consequently, the calibrated attenuator must not lie ahead of the input of the test receiver, but in the IF channel where, because of the low frequency, much higher accuracies can be reached with less elaborate means.

attenuation. Thus, the test receiver allows attenuation measurements to be made with the precision of very accurate attenuation boxes.

The measurement itself is very simple. Connect the test item (a coiled cable in Fig. 2) between test receiver and signal generator and mark the deflection on the meter of the receiver; next, remove the test item, connect the test receiver directly to the signal generator and adjust the gain to the same deflection using the attenuator of the receiver. The attenuation measured is the difference of the two attenuator settings in db. Check, before each measurement, the test item, the generator, the receiver and the leads for equal characteristic impedances. If this check reveals mismatch or if mismatch is suspected from the beginning, use matching pads (which can be clearly seen in Fig. 2). These are 10-db attenuator pads which are to be connected to the ends of the leads between which the test item will be placed. Corresponding to the commonly used characteristic impedances of 50,

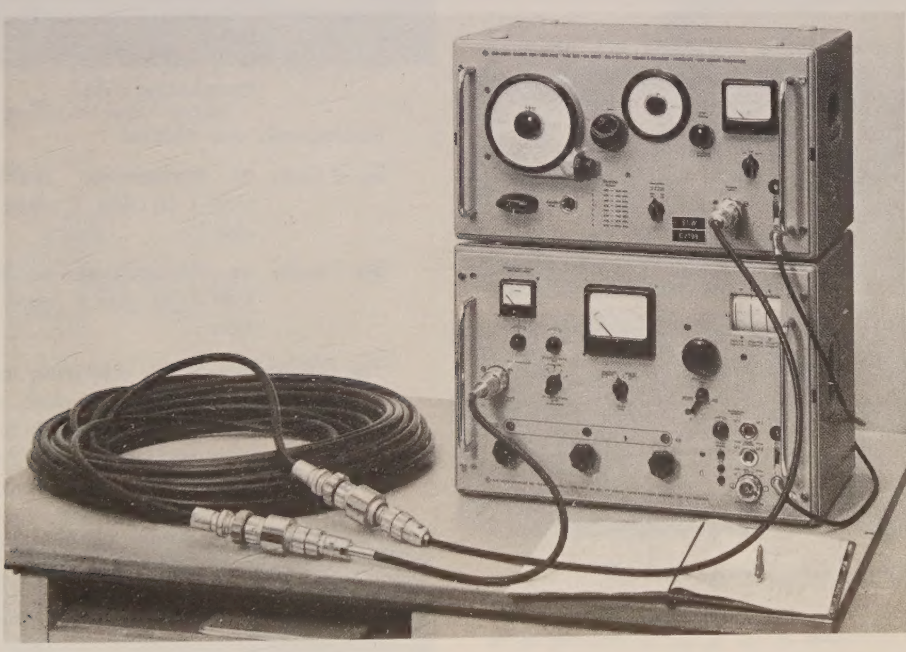


Fig. 2 Measuring the attenuation of a cable, using the Test Receiver Type USVD. The test item is separated by means of two attenuator pads of 10 db each.

The Test Receivers Types USVD and USVU have decade attenuators in the IF channel. They cover 70 db (for measurement: 60 db), adjustable in steps of 10 db, 1 db and 0.1 db. The respective operating frequencies are so low for the attenuators that the calibration accuracy is about ± 0.2 db over the entire measurement range of 60 db. The error decreases with the

60 and 75 Ω, matching pads with these values are available. Only the accurately defined impedance value of the matching pad is present at the junction plane, since any unwanted mismatch is heavily reduced by a high attenuation. Thus, two equal standard impedances appear as generator and as termination, seen from the test item. This separation method, which avoids

any mismatch from the connection side, has found general acceptance in UHF engineering. If the characteristic impedances of the test item and of the test rig are identical, the image attenuation is measured; if they are not identical – which is generally the case – the insertion loss is measured. The insertion loss is practically equal to the image attenuation as long as the mismatch at the test item does not exceed 20 %.

3. Determining the Scattering Matrix with Reflectometer, Terminating Resistor and Receiver

Generally, the current-voltage matrixes, i. e. impedance matrix, admittance matrix, iterative matrix and series-parallel matrix, are used for describing two-ports. They are taken from the two-port equations, where currents and voltages are related. The current measurement is problematic in high-frequency engineering. A distinction is made between incoming, outgoing, standing and reflected waves.

The convenient wave equations are obtained when the incoming waves of a two-port are related to the outgoing ones.

Their coefficients form the so-called wave matrixes [1] which have been introduced only recently. In Fig. 3, the waves coming into the two-port are designated by a_1, a_2, whereas those going out of the two-port are designated by b_1, b_2. The relations between the waves are linear as is true also for current-voltage equations. Hence the outgoing b_1-, b_2-waves may be written as a linear function of the incoming a_1-, a_2-waves.

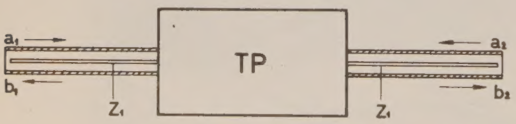


Fig. 3 The four waves a_1, a_2, b_1 and b_2 occurring at the terminals of a two-port.

$$\begin{aligned} b_1 &= S_{11}a_1 + S_{12}a_2 \\ b_2 &= S_{21}a_1 + S_{22}a_2. \end{aligned} \qquad (1)$$

The scattering matrix – an easy-to-read way of writing the factors S_{mn} – then is

$$S = \begin{Vmatrix} S_{11} & S_{12} \\ S_{21} & S_{22} \end{Vmatrix}$$

The two-port must continue, at both ends, in homogeneous lines in order to make possible a distinction between the incoming and outgoing waves. The easiest way is to consider the two-port as being connected, to the right and to the left, to a slotted line where the pick-up probe permits two waves running against one another to be located. In their definition, the scattering matrixes make sense only if it is known between which lines (amount of the characteristic impedance Z_1) the two-port is connected. In practice, only the standardized characteristic impedances of 50, 60 and 75 Ω come into question. If it is assumed that the unknown two-port is connected into a 50-Ω line system, the wave a_2 can be made zero by terminating the two-port at the right side with a good terminating resistor of 50 Ω. The wave b_2 is then entirely absorbed by the terminating resistor, so that no reflection occurs. Putting $a_2 = 0$ in the equation (1), one obtains

$S_{11} = b_1/a_1$ as the input reflection coefficient when terminating side 2.

Changing the terminating resistor over to the left side of the two-port and changing the feeding over to the right side, the wave a_1 becomes zero and one obtains with equation (1)

$S_{22} = b_2/a_2$ as output reflection coefficient when terminating side 1.

Analogously one obtains

$S_{21} = b_2/a_1$ as transmission coefficient from side 1 to side 2 when terminating side 2.

$S_{12} = b_1/a_2$ as transmission coefficient from side 2 to side 1 when terminating side 1.

The coefficients of the scattering matrix are, of course, complex quantities which must be determined with respect to magnitude and angle. In many cases, however, only their absolute value is of interest. The measurement with the reflectometer, determining the incident and reflected waves individually, thus becomes very simple (Fig. 4).

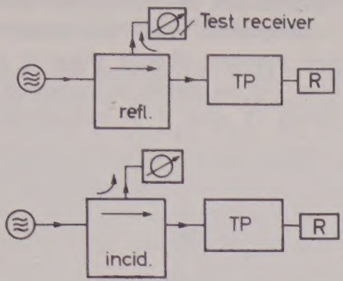
For the determination of $|S_{11}|$ connect the reflectometer to the input of the test item and the terminating resistor to the output. The input reflection coefficient is the ratio between the reflected and the incident wave.

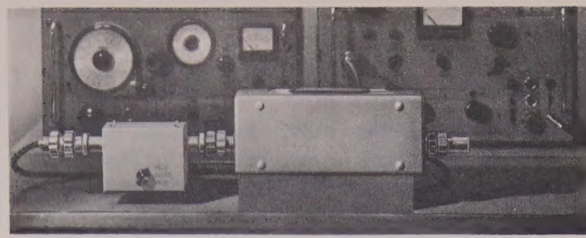
$|S_{22}|$ can be measured if the reflectometer is at the output of the test item and the terminating resistor at the input. The output reflection coefficient is the ratio between the reflected and the incident wave.

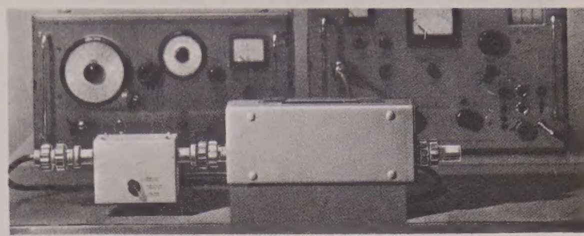
To determine $|S_{21}|$, connect the reflectometer first to the output of the test item, while the terminating resistor terminates the free end of

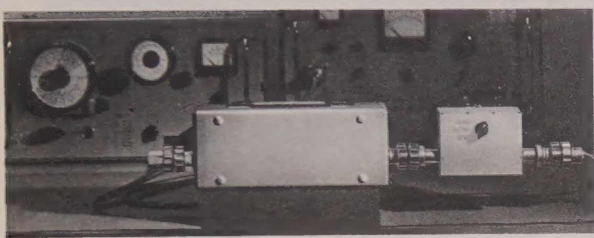
Reflection coefficient at the input

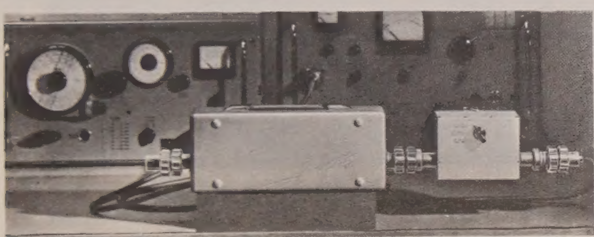
$$S_{11} = \frac{E_{r\,1}}{E_{i\,1}}$$





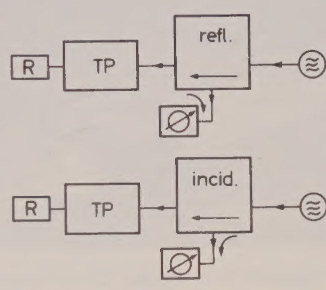






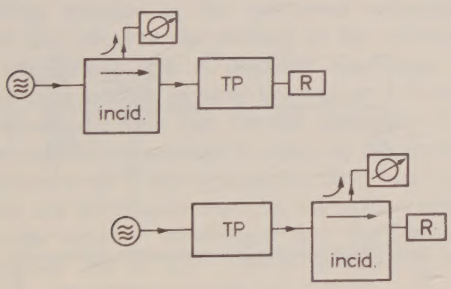
Reflection coefficient at the output

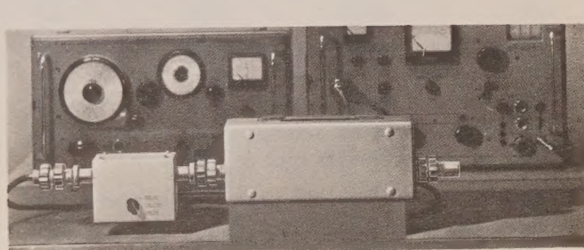
$$S_{22} = \frac{E_{r\,2}}{E_{i\,2}}$$

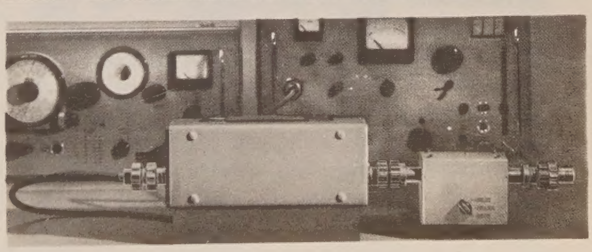


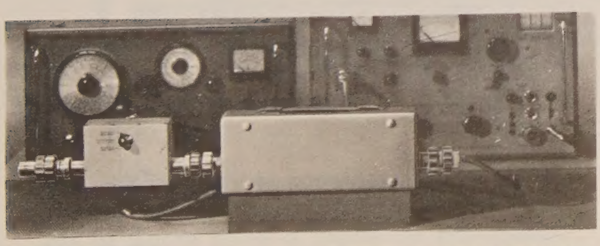
Transmission coefficient input-output

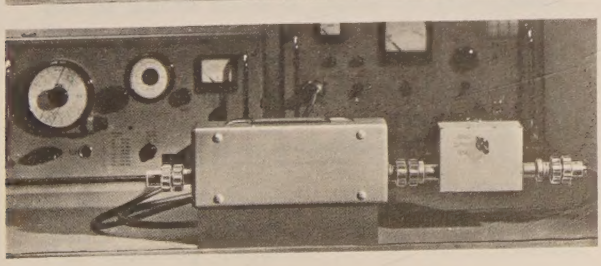
$$S_{21} = \frac{E_{i\,3}}{E_{i\,1}}$$











Transmission coefficient output-input

$$S_{12} = \frac{E_{i\,4}}{E_{i\,2}}$$

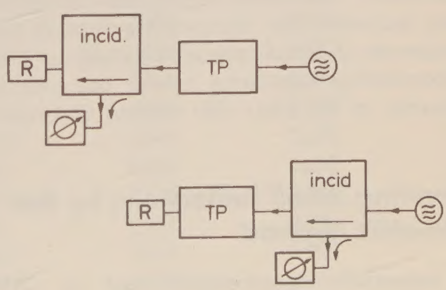


Fig. 4 Measuring the coefficients of the scattering matrix, using the reflectometer and the terminating resistor

the reflectometer. Next, remove the reflectometer, connect it to the input of the test item without changing the direction, and connect the terminating resistor to the free output of the test item. In both cases, the test receiver is connected to the probe picking up the incident wave. The transmission coefficient $|S_{21}|$ is the ratio between the wave going out of the test item and the wave entering the test item or the difference of the db settings if the meter deflection on the receiver is kept constant.

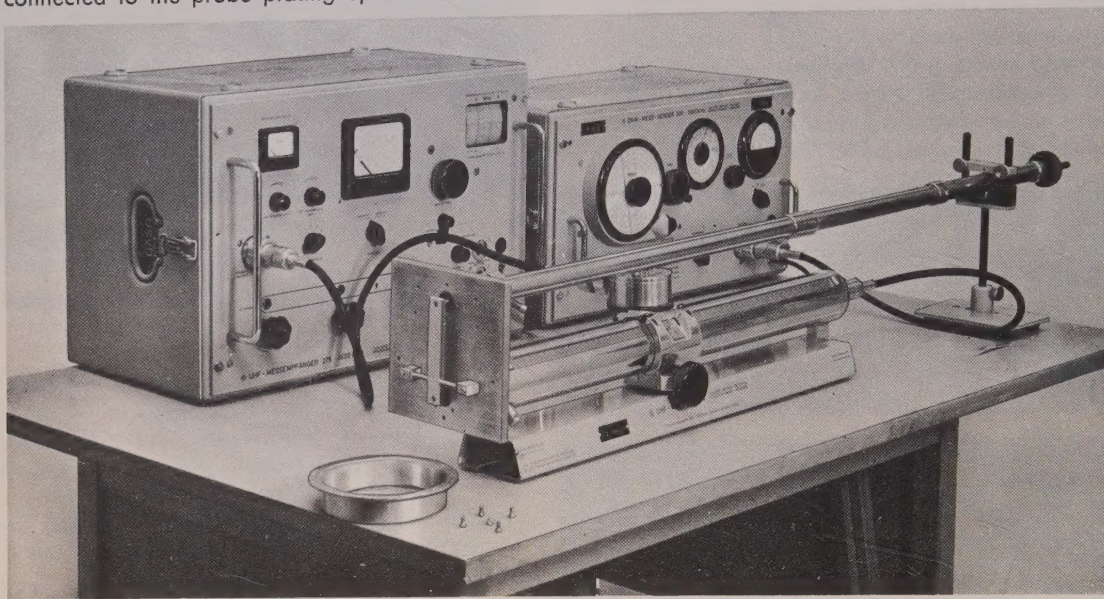


Fig. 5a Measuring the reflection of a U-shaped line for the TV Bands IV and V by the node-shift method

Proceed in the reverse order when measuring the transmission coefficient $|S_{12}|$. Connect the reflectometer first to the input of the test item and terminate its free end with the terminating resistor. Then change the position of the reflectometer and terminate the test item at its input. The transmission coefficient $|S_{12}|$ is the ratio between the wave going out of the input and the incoming wave. The substitution measurement with the receiver is made as described above.

The error sources, which might be due to unequal coupling probes in the case of different reflectometers, are excluded, since one and the same reflectometer is used throughout this measurement. This measuring method, therefore, is very accurate. The energy flow through the reflectometer is practically undisturbed, so that the terminating impedance at the one side is transferred to the other side without distortion.

4. Measuring Small Reflections by the Node-shift Method

The node-shift measurement used in UHF engineering is another typical measurement of small reflection coefficients. This method permits equalization of transmission-line elements which, as frequently used components of instruments and systems, should show a particular reflection. Fig. 5a shows a U-shaped line section for Bands IV and V in connection with a slotted

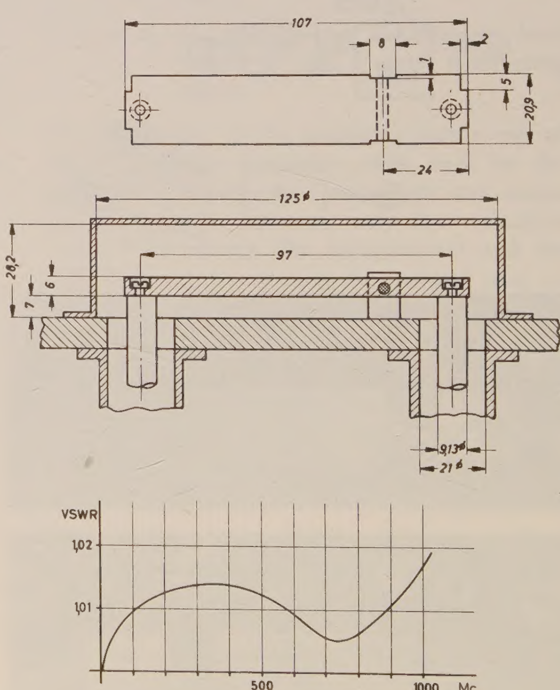


Fig. 5b Mechanical dimensions and the obtainable reflection curve of the shown U-shaped line for a characteristic impedance of 50 Ω

line and a calibrated adjustable short. The Test Receiver Type USVD serves for the indication, the Signal Generator Type SDR for feeding.

The connection of the two coaxial lines is made with a strip line which is vertically connected to the inner conductors projecting from the base plate. It is necessary to mutually adjust the width of the strip line and its distance from the base plate in such a way that the reflection reaches the desired minimum value. Moreover, the edges of the strip line must be cut back immediately at the transition to the coaxial line, since there occurs an excess capacitance which should be compensated for at the same point, if possible. Fig. 5b shows the mechanical dimensions together with the reflection curve obtained. This equalization, which can be made only by the cut-and-try method, is very tedious. 20 to 30 curves with 6 test points each must be plotted for the example shown, even if great experience is involved. It is very important in this connection that the measuring instruments used facilitate the work as much as possible.

It is of great importance that the receiver is very sensitive, to permit the minimum on the slotted line to be located accurately and without any complicated interpolation. Before starting the measurement, provide the test item, or a model thereof, with the Dezifix connector. In this way, a convenient connection is obtained to the slotted line and the calibrated adjustable short. The reflection of the connectors itself is negligible. Next, change the position of the shorting plunger in the calibrated adjustable short and observe the shifting of the minimum on the slotted line. A detailed description of the evaluation has already been given [2]. It may be mentioned here that the full sensitivity of a superheterodyne receiver is required for finding a minimum of a few microvolts. Such measurements are reasonable from an economical point of view only if instruments are used whose properties are at least similar to those of the Test Receivers Types USVD and USVU.

5. Model Measurements

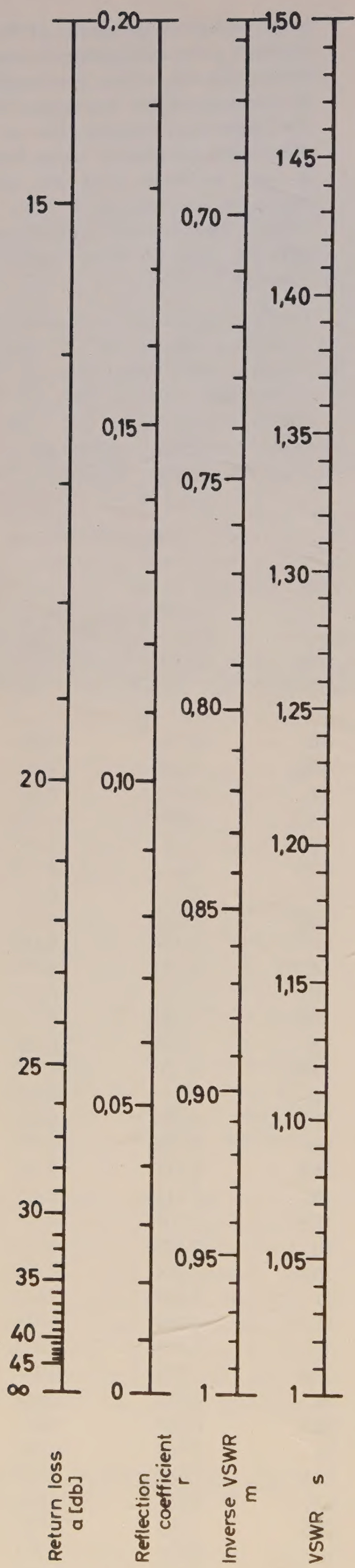
The dimensions of the connecting line in Fig. 5a are still such that the calibrated adjustable short can be placed above or beside the slotted line. There are cases where the measurement must be made on line sections which are much shorter than the distance between the inner conductors of the slotted line and the calibrated adjustable short which are close to one another.

In this case an enlarged model must be built and the measurements be made on this model. The measuring frequency for this scale model is the operating frequency of the original unit, divided by the enlargement factor. For example, if the scale model has been made twice as big as the original, the measuring frequency is half the operating frequency. The measuring procedure is thus transferred to low frequencies which is very desirable since the accuracy of the measuring instruments is then higher. Scale-model measurements, therefore, are rather popular, even if there exists no mechanical necessity for them.

The foregoing examples show that the available measuring voltages in UHF engineering often are so small that sensitive superheterodyne receivers are required. The Test Receivers Type USVD 300 to 900 Mc and Type USVU 900 to 2700 Mc suggest themselves as economical standard instruments for the UHF laboratory.

The numerical relationship between return loss a, reflection coefficient r, inverse VSWR m and VSWR s is given below.

Return loss a (db)	Reflection coefficient r	Inverse VSWR m	VSWR s
10	0.316	0.520	1.923
10.5	0.298	0.541	1.848
11	0.282	0.561	1.780
11.5	0.266	0.579	1.726
12	0.252	0.598	1.671
12.5	0.237	0.618	1.618
13	0.224	0.634	1.578
13.5	0.211	0.650	1.538
14	0.199	0.668	1.497
14.5	0.188	0.684	1.462
15	0.178	0.699	1.430
15.5	0.165	0.716	1.396
16	0.158	0.727	1.374
16.5	0.150	0.740	1.350
17	0.141	0.752	1.329
17.5	0.133	0.766	1.304
18	0.126	0.777	1.285
18.5	0.119	0.789	1.268
19	0.112	0.799	1.251
19.5	0.106	0.809	1.235
20	0.100	0.819	1.220
20.5	0.094	0.828	1.208
21	0.089	0.837	1.193
21.5	0.084	0.846	1.180
22	0.079	0.853	1.171
22.5	0.075	0.861	1.160
23	0.071	0.868	1.151
23.5	0.067	0.875	1.142
24	0.063	0.882	1.133
24.5	0.060	0.888	1.124
25	0.057	0.894	1.118
25.5	0.053	0.900	1.111
26	0.050	0.904	1.105
26.5	0.047	0.909	1.100



Return loss a (db)	Reflection coefficient r	Inverse VSWR m	VSWR s
27	0.045	0.914	1.094
27.5	0.042	0.919	1.088
28	0.040	0.924	1.082
28.5	0.038	0.928	1.078
29	0.035	0.932	1.073
29.5	0.034	0.934	1.069
30	0.032	0.938	1.064
30.5	0.030	0.942	1.060
31	0.028	0.945	1.056
31.5	0.027	0.947	1.054
32	0.025	0.951	1.051
32.5	0.024	0.953	1.048
33	0.022	0.956	1.045
33.5	0.021	0.958	1.043
34	0.020	0.961	1.040
34.5	0.019	0.963	1.038
35	0.018	0.965	1.036
35.5	0.017	0.967	1.034
36	0.016	0.969	1.032
36.5	0.015	0.971	1.030
37	0.014	0.972	1.028
37.5	0.013	0.974	1.027
38	0.013	0.975	1.025
38.5	0.012	0.976	1.024
39	0.011	0.978	1.022
39.5	0.011	0.979	1.021
40	0.010	0.980	1.020
40.5	0.009	0.980	1.020
41	0.009	0.982	1.018
41.5	0.008	0.983	1.017
42	0.008	0.984	1.016
42.5	0.008	0.985	1.015
43	0.007	0.986	1.014
43.5	0.007	0.987	1.013
44	0.006	0.988	1.012
44.5	0.006	0.988	1.012
45	0.006	0.989	1.011
45.5	0.005	0.989	1.011
46	0.005	0.989	1.011
46.5	0.005	0.990	1.010
47	0.004	0.991	1.009
47.5	0.004	0.992	1.008
48	0.004	0.992	1.008
48.5	0.004	0.993	1.008
49	0.004	0.993	1.007
49.5	0.003	0.993	1.007
50	0.003	0.994	1.006

$a = 20 \log_{10} \frac{E_i}{E_r}$ $\quad r = \frac{E_r}{E_i}$ $\quad m = \frac{E_{min}}{E_{max}}$ $\quad s = \frac{E_{max}}{E_{min}}$

$a = 20 \log_{10} \frac{1}{r}$ $\quad r = 10^{-a/20}$ $\quad m = \frac{1}{s}$ $\quad s = \frac{1}{m}$

$a = 20 \log_{10} \frac{1+m}{1-m}$ $\quad r = \frac{s-1}{s+1}$ $\quad m = \frac{1-r}{1+r}$ $\quad s = \frac{1+r}{1-r}$

$a = 20 \log_{10} \frac{s+1}{s-1}$ $\quad r = \frac{1-m}{1+m}$

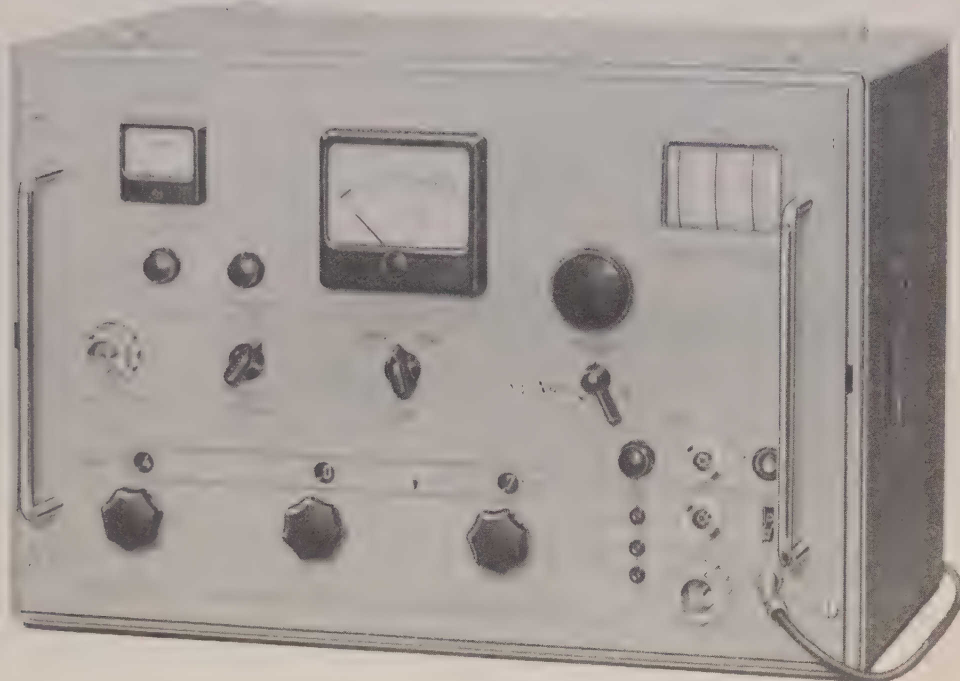
References

[1] E. Schuon and H. Wolf, NTZ 1959, No. 7, page 361
[2] A. Kraus, R&S-Mitteilungen, No. 8/1956, page 2

A. Kraus

UHF TEST RECEIVER 280 to 940 MC

with Harmonic Operation up to 4600 MC



Specifications

► Order Number BN 1523/50 or /60

Principle	superheterodyne receiver with broadband input
Fundamental frequency range	280 to 940 mc
Frequency range with harmonic operation	up to 4600 mc (operating with harmonics from local oscillator)
Frequency range of the local oscillator	305 to 915 mc
Intermediate frequency	25 mc
Calibration of the frequency scale	
Fundamental frequency range ($f_{osc} - f_{if}$)	280 to 890 mc
Fundamental frequency range ($f_{osc} + f_{if}$)	330 to 940 mc
Range of the 3rd harmonic ($3\ f_{osc} + f_{if}$)	940 to 2750 mc
Range of the 5th harmonic ($5\ f_{osc} + f_{if}$)	1600 to 4600 mc
Noise figure in the fundamental frequency range	15 to 16 db in case of a voltage source with a source impedance of 50 to 60 Ω
Sensitivity loss with harmonic operation	
with the 3rd harmonic	about 10 to 20 db
with the 5th harmonic	about 15 to 25 db
Measuring range	
in the fundamental frequency range	30 µv to 30 mv (60 db)
with harmonic operation	about 300 µv to 30 mv (40 db)
Voltage indication	by pointer type meter
Voltage calibration, relative	(a) attenuator: in decibels (b) meter: proportional to voltage
Attenuator steps	6 x 10 db / 10 x 1 db / 10 x 0.1 db
Accuracy when measuring voltage ratios with the	attenuator
in the fundamental frequency range	±1% of the db value ±0.1 db
with harmonic operation	about ±5% of the db value ±0.1 db
Input (R&S connector Dezifix B*)	50 Ω for BN 1523/50, 60 Ω for BN 1523/60
I-f bandwidth	2 mc
I-f output	R&S connector Dezifix B*, open-circuit voltage about 0.6 V_{rms}, output impedance 60 Ω

* Receivers with other connectors can be supplied. Please specify desired type accurately.

UHF TEST RECEIVER USVD

Demodulation	for AM
Outputs for the demodulated signal	
I: Broadband, high impedance	13-mm socket, 100 cps to 200 kc, about 60 v_{pp} into more than 50 kΩ
II: Broadband, low impedance	13-mm socket, 20 cps to 1 mc, open-circuit voltage about 0.5 v_{pp}, output impedance 75 Ω
III: For head-phones	telephone jacks, 500 to 2000 cps, 0 to 2 v_{rms}, variable, into about 4 kΩ

The voltage values at the outputs correspond to full-scale deflection on the meter, those specified for the demodulated signal referring to 50% modulation.

Power supply	115/125/220/235 v $^{+10}_{-15}$%, 47 to 63 cps (165 va)
Dimensions	540 x 370 x 378 mm (R&S Standard Cabinet 510)
Weight	38 kg

Uses

The UHF Test Receiver Type USVD has been designed as a superheterodyne receiver for relative voltage measurements in the frequency range 280 to 940 mc. This frequency range is extended up to 4600 mc when the input signal is mixed with the harmonics of the local oscillator instead of with the fundamental frequency.
The instrument is capable of measuring voltage ratios very accurately. For example, it lends itself to measuring voltage standing wave ratios, particularly if these are extremely large. Further applications are found in the calibration of attenuators, determination of the attenuation characteristic of filters and measurement of field-strength variations. Another use is as a null detector for bridges. The possibilities mentioned in the above examples deal with relative voltage measurements which represent the majority of the cases encountered in practice. If it is necessary to refer the voltage measurement made with the Type USVD to an absolute calibration, it is possible to provide this calibration with the aid of a signal generator, such as our Types SDR, SCR or SBR.
The amplified intermediate frequency of the UHF Test Receiver is available at a front-panel output whence it can be derived for further measurements. Using, for instance, the Frequency Deviation Meter Type FMV, it is possible to measure the frequency swing or amplitude modulation of transmitters which apply a minimum of 30 µv to the input of the Type USVD. The Type USVD then functions as the pre-amplifier and frequency converter, enabling the subsequent measurement to be made.
Two broadband outputs, one low- and one high-impedance, for the modulation frequency increase the versatility of the set. They can be used, for example, to feed into an oscilloscope via an amplifier or directly to the deflection plates. In addition, there is an output for a headset.

Description

The UHF Test Receiver Type USVD has at its input an untuned crystal mixer to which the local oscillator voltage is applied in push-pull, whereas the incoming signal enters via a parallel arrangement. The reradiated oscillator voltage appearing at the receiver input is hence very small. A high-pass filter rejecting straight-through i-f signals has been inserted between the input and the mixer. The rectified r-f voltage of the mixer diodes is indicated on a meter, so that overloading of the diodes by too high an input voltage is noticed immediately. A front-panel control permits adjustment of the local oscillator voltage to the optimum-value mark on the meter which reads the rectified current.
The local oscillator covers the frequency range 305 to 915 mc by contactless variation of the characteristic impedance, and without switching. Mixing is possible with the fundamental frequency as well as with the third or fifth harmonic of the local oscillator. A flywheel drive of high gear ratio permits very sharp tuning and rapid coverage of the entire range.
The attenuator provided in the form of a standard attenuator has been inserted between the mixer and i-f amplifier. The mixer possesses a strictly linear characteristic in the specified voltage range, a change in receiver input voltage hence resulting in an exactly proportional change in i-f voltage. This change can be compensated by varying the attenuation of the attenuator while observing the meter connected to the output of the i-f amplifier. The attenuator setting then corresponds exactly to the voltage variation at the receiver input.
The i-f amplifier is of the four-stage type. Fine and coarse adjustment of its gain is possible by controlling the grid bias of one stage. After rectification, the amplified i-f voltage is indicated on the associated meter whose calibration is relative. A switch permits selection of a normal or spread range. The above-mentioned output for the intermediate frequency is isolated by a buffer stage so that loading does not affect the reading.
The demodulation of the intermediate frequency is followed by a wideband amplifier. The audio signal amplified therein is passed on to high- and low-impedance outputs as well as to a headphone socket, via an a-f low-pass filter. The anode and filament voltages of the oscillator, the i-f and wideband a-f amplifiers are electronically stabilized.

Valve complement: 1 x DL 41, 1 x EC 55, 3 x EF 40, 6 x EF 80, 5 x PL 81, 2 x 85 A 1

We reserve the right to make any departures from this specification, especially those considered desirable for reasons of improved design.

UHF TEST RECEIVER 0.9 to 2.7 GC

Specifications	▶ Order Number BN 1524
Principle	superheterodyne receiver with broadband input
Frequency range	0.9 to 1.9/1.7 to 2.7 Gc
Input	R&S connector Dezifix B +) (nominal 60 Ω)
Sensitivity	-90 dbm (corresponding to about 8 μv) with a signal-to-noise ratio of appro 7 db
Total measurement range	80 db (-90 to -10 dbm)
Individual measurement ranges	
on panel meter	
Scale I (relative)	0.3 to 1 } proportional to voltage
Scale II (relative)	0.7 to 1 } proportional to voltage
Scale III (absolute calibration possible)	-90 to -50 dbm
Scale IV (absolute calibration possible)	-90 to -80 dbm
with built-in IF attenuator	70 db with the steps 6 x 10 db/ 10 x 1 db/10 x 0.1 db
Absolute calibration	by adjusting the inherent-noise deflection on panel meter to a definite scale mark

+) Instruments with other connectors can be supplied. Please specify desired type accurately.

Accuracy	
of the absolute power measurement	± 2 db
of the relative measurement by means of calibrated attenuator within a range of -80 to -20 dbm	± 1% of db value ± 0.1 db
Intermediate frequencies	1st IF: 250 Mc, 2nd IF: 25 Mc
IF bandwidth	2 Mc
IF output	R&S connector Dezifix B +) 25 Mc, 60 Ω, 1 v open circuit ++)
Recorder output	telephone jacks, 0.6 MΩ, 3 v open circuit ++) (floating)
Demodulation	for AM
Oscilloscope output	13-mm socket +) 10 cps to 1 Mc, 75 Ω, 1 v_{pp} open circuit for 100 % modulation ++)
Headphone output	telephone jacks 0.3 to 3 Kc, 3 KΩ, 1 v open circuit for 100 % modulation ++)
Tuning indication	by discriminator and panel meter
Automatic frequency control	by means of the UHF oscillator vernier drive actuated from a servo-motor; may be switched off
Valves, etc.	
Valves	1 x DL 92, 1 x E 81 L, 1 x E 180 F 3 x E 280 F, 2 x EC 56, 1 x EC 80 1 x EC 81, 1 x ECC 83, 3 x EF 80 3 x EF 800, 5 x PL 81
Reference tubes	2 x 85 A 2
Crystal diodes	4 x 1 N 416 C
Miniature glow lamp	1 x RL 210
Fuse	1 x 1.6 amps 1,6 D DIN 41571
Power supply	115/125/220/235 v $^{+10}_{-15}$ %, 47 to 63 cps (175 va)
Dimensions (W x H x D)	540 x 370 x 430 mm (R&S Standard Cabinet 5101)
Weight	51 kg

+) Instruments with other connectors can be supplied. Please specify desired type accurately.

++) The specified voltage value is valid for full-scale deflection on meter.

Uses

The UHF Test Receiver Type USVU is a selective, highly sensitive instrument for measuring power, voltage and field strength in the range 0.9 to 2.7 Gc.

A wide range of problems in UHF engineering involve a comparison of two powers or voltages of the same frequency, i.e. a measurement of relative values. For example, relative values are indicated in reflection-coefficient measurements with a reflectometer, impedance measurements with a slotted line, calibration work for attenuation pads, insertion loss or gain measurements on all types of two-port networks, plotting of filter curves, etc.

Because of its selectivity, high sensitivity and wide linear measurement range, the superheterodyne receiver is superior to all other receiving arrangements, such as a detector followed by an amplifier.

The UHF Test Receiver Type USVU permits relative-value measurements of the highest accuracy to be made within a range of 60 db (from -80 to -20 dbm), using a built-in attenuator. Small voltage ratios, as occur when measuring a small VSWR on a slotted line, may be read directly on one of the two calibrated voltage scales of the panel meter. The accuracy of the relative calibration of the panel meter can be checked with the built-in attenuator whose accuracy is independent of aging. The measurement range can be extended to 80 db (from -90 to -10 dbm) provided a measurement error of approx. 1 db is tolerable at the limits of the measurement range.

The Type USVU also finds use as an absolutely calibrated, selective UHF power meter for, e.g., the quantitative investigation of harmonic spectra of signal sources, harmonic generators, etc.

In conjunction with a suitably calibrated antenna, the Type USVU functions as a field strength meter. The UHF Parabolic Antenna Type HA 262/1 was developed for this purpose. With this antenna and the Test Receiver Type USVU, a field-strength sensitivity of 35 μv/m is obtainable.

In order to avoid disturbing the field-strength measurements by an image signal of the frequency being measured, a Switchable UHF Bandpass Filter Type PBA BN 49141 is provided for connection between the parabolic antenna and receiver. The entire above-mentioned equipment is designated "UHF Field Strength Measuring Equipment Type HFA, BN 15003".

The field-strength measuring equipment finds application for investigating propagation conditions in the planning of radio directional links. It is also used for measuring the gain and directional characteristics of antenna installations and detecting stray radiations from superheterodyne receivers, signal generators, etc.

It is often desired to record the field-strength variations of a transmitter over long periods of time. For this purpose, the Type USVU is provided with connectors for a recording instrument. Recording is possible in each scale range of the panel meter. Especially suited is our DC Recorder Enograph G Type ZSG, BN 18531 or BN 18532, respectively. This arrangement is also suitable for tracing radiation patterns since the paper drive of the Enograph G can be coupled to the antenna system and driven proportionally to its azimuth angle.

To keep the receiver tuned to the transmitter frequency over long periods of time, especially when recording, the Test Receiver Type USVU contains an automatic frequency control circuit which limits the maximum frequency deviation from the centre of the passband to ±30 Kc.

The UHF Test Receiver Type USVU is furthermore used to investigate the modulation characteristics of amplitude- or frequency-modulated transmitters with modulation bandwidths up to 1 Mc. For this purpose, the amplified IF frequency, 25 Mc, can be taken from an output and used, e.g., for measuring the degree of amplitude modulation or frequency deviation by means of a suitable instrument, such as our Frequency Deviation Meter Type FMV BN 4620. An oscilloscope output permits display of amplitude-modulated signals.

UHF Test Receiver Type USVU

Description

The received frequency is converted in a mixer stage to an intermediate frequency of 250 Mc. The power at the 1st intermediate frequency, being proportional to the power at the receiver input, is applied to a calibrated attenuator for relative-value measurement. The frequency is then again changed; this time to 25 Mc. The power at the 2nd intermediate frequency is further amplified and then applied to a rectifier meter. If two UHF powers or voltages are to be compared with one another, the calibrated attenuator is adjusted in both cases for producing the same deflection on the panel meter. The power ratio can then be read in db directly from the attenuator.

With this method, a high relative-value measurement accuracy independent of frequency can be reached since the mixer and RF amplifier stages function in an exactly linear manner because of their low signal levels. Also contributing to the high accuracy is the fact that the calibrated attenuator is fed from the constant frequency of 250 Mc.

A slight non-linearity after the calibrated attenuator does not affect the measurement accuracy so that it remains unchanged during the aging of the amplifier valves and rectifiers.

The absolute calibration of the receiver is based on the fact that its noise figure is nearly independent of frequency. The noise power apparently present at the receiver input can thus be used as a reference power level. The absolute calibration is accomplished by adjusting an IF gain control until the inherent noise produces a deflection to a definite scale mark on the panel meter.

Construction

The UHF signal at the receiver input passes through an input filter suppressing straight-through IF signals. Depending upon the position of the frequency-range switch (0.9 - 1.9 or 1.7 - 2.7 Gc), the signal is then applied to one of the two mixing heads, each containing two low-noise silicon diodes connected in push-pull. Each of the two mixing heads has its own oscillator covering a 500-Mc range. Since for each oscillator frequency one receiving frequency is 250 Mc (IF) below and another 250 Mc above the oscillator frequency, the total receiving range covered by each oscillator is 1000 Mc. Both oscillators are tuned by a common coarse-fine drive which makes possible both rapid frequency changing and exact fine adjustment. The oscillator voltage can be manually controlled. A panel meter, which shows the rectified diode-mixer current, permits exact adjustment of the optimum oscillator voltage.

The 250-Mc IF from the mixing heads is amplified in a low-noise pentode before being applied to the calibrated attenuator. After another conversion, the resulting 25-Mc signal is again amplified and then rectified. The rectified voltage is then applied to a panel meter and recorder output in addition to a broadband AF amplifier stage. The voltage from the rectifier is also used to control the gain of two IF amplifier stages when the receiver is switched to the logarithmic measurement range, Scale III. The gain of these amplifier stages can also be controlled manually.

The signal from the last IF stage passes via a buffer stage to the IF output and via a limiter to a discriminator. Its DC output voltage feeds a tuning meter and, via a relay, controls a tuning motor directly coupled to the oscillator fine-tuning drive.

All operating voltages of the Type USVU are electronically stabilized so that excellent performance of the set is ensured even under adverse supply-voltage conditions.

1260-Rot 4742 E

Edition December 1960

Instructions for the Modification of the IF Output of the VHF Monitoring Receivers Types ESM 180 and ESM 300

The VHF Monitoring Receivers Types ESM 180 and ESM 300 are superheterodyne receivers designed for radio monitoring and radio-interference control in the VHF band. They enable both amplitude- and frequency-modulated signals to be received in the ranges 30 to 180 and 85 to 300 Mc. An output for connection of an oscilloscope permits pulse-modulated waves and interfering frequencies to be displayed. Since the input voltage is indicated on a meter, this receiver, in conjunction with a standardizing oscillator, can also be used for field-intensity measurements.

The incoming signal is first amplified in two VHF stages. It is next heterodyned with the frequency of the 1st local oscillator, and then applied to the 4-stage intermediate-frequency amplifier. In narrow-band operation, the intermediate frequency of 21.4 Mc is converted to 3.4 Mc. One stage in the IF section operates as an amplitude limiter when frequency-modulated signals are received. For FM demodulation, separate ratio detectors are provided for the two intermediate frequencies. AM demodulation is achieved by means of crystal diodes.

VHF Monitoring Receiver

For connection of an oscilloscope, the intermediate frequency, demodulated ahead of the limiter, is applied to a cathode follower which feeds modulation frequencies of up to 100 kc to the output for the oscilloscope. Furthermore, the low-impedance IF output of the receiver permits AM measurements at the intermediate frequency. The AF output signal is fed to the built-in loudspeaker which can be switched out of circuit.

In conjunction with the Radio Interference Indicator Type EZS and the Calibration Oscillator Type SEP,

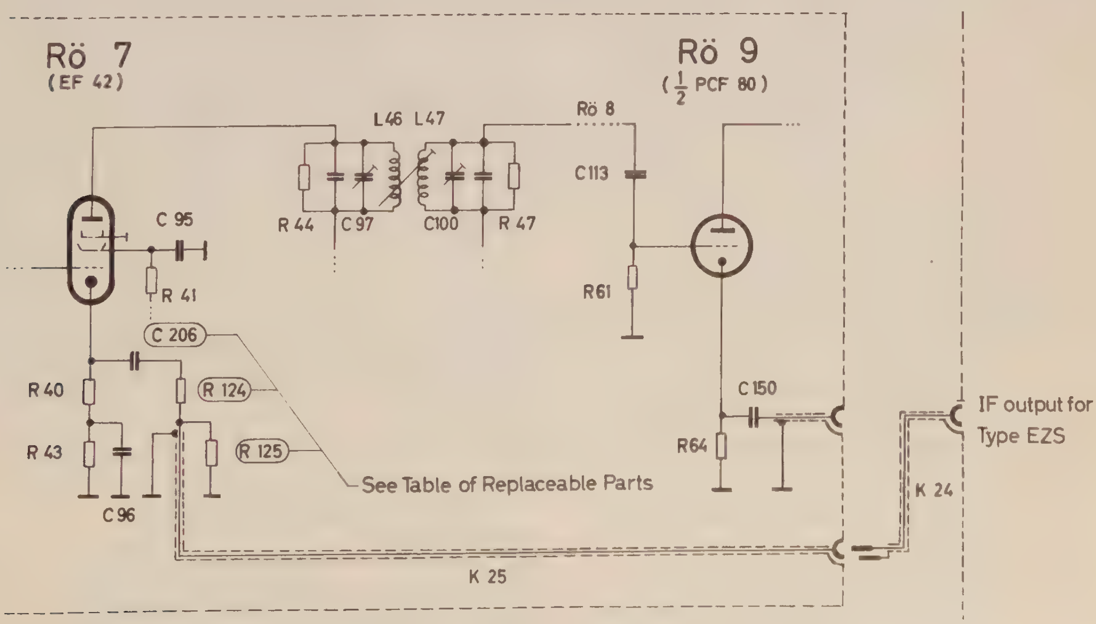


Fig. 1 Circuit diagram for the modification

the R&S receivers can be employed for radio-interference measurements. For this purpose, it is advisable to bring out the IF voltage of the receivers Types ESM 180 and ESM 300 2 stages sooner. This prevents overdriving and, consequently, higher voltages can be applied to the receiver input, which also improves the signal-to-noise ratio.

The procedure for obtaining this second (low-impedance) output is simple. No changes are necessary on the front panel. After the modification has been made as set forth below, the IF output socket on the front panel can be either connected to the second or to the fourth IF stage by merely changing over a cable inside the set.

place with 2 screws M 3 x 5 (DIN 84) and pass cable K 25 through the 5-mm hole. Fig. 2 gives a lateral cut-away view of the angle piece.

e) Soldering lug KL 331 (Fig. 3) serves as earthing point for the other end of the cable shield K 25. For fastening to the partition wall, use the screw which is secured in position by a clamp in the adjacent chamber.

f) As shown in the circuit diagram (Fig. 1), connection is made to the cathode of valve Rö 7 via the resistors R 125, R 124 and the capacitor C 206.

II a) Replace the IF section.

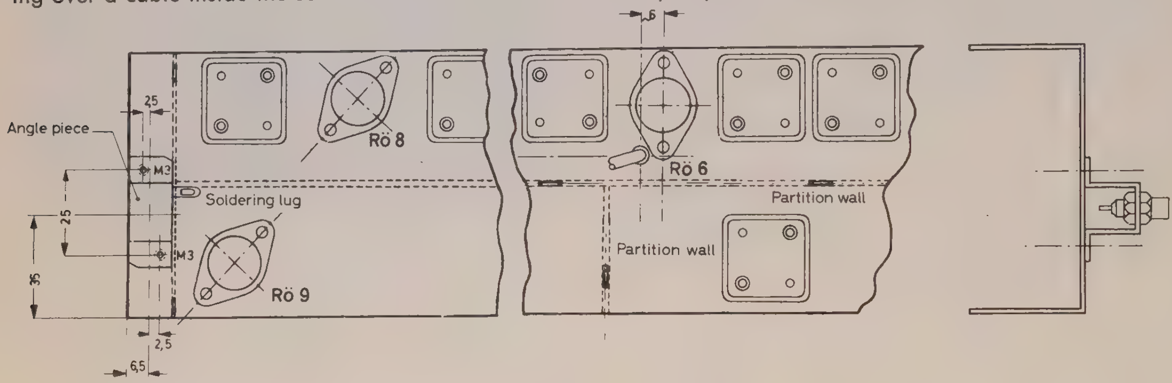


Fig. 2 Top view of the IF section

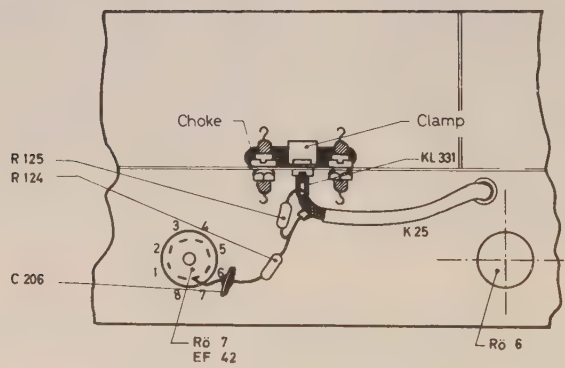


Fig. 3 Bottom view of the IF section

For the modification, proceed as follows:

I a) Obtain the modification set specified in the adjacent column.

b) Remove the IF section.

c) Fix the angle piece according to drawing (Fig. 2); to hold it in place, drill two holes with a diameter of 2.4 mm and tap them for M 3 screw threads.

For the cable passage, drill a hole of 5 mm diameter near valve Rö 6.

d) Connect cable K 25 to socket FD 406/3 which is mounted to the angle piece. A soldering lug provided on the angle piece permits connection of the shield. Screw angle piece in

b) Connect cable K 24 to the socket provided on the angle piece.

The modification set for the superheterodyne receivers Types ESM 180 / ESM 300 is available under the No. R 7269 b. It consists of the following individual parts:

1 angle piece with built-in socket
1 RF cable (K 25), 400 mm long
2 cheese-head screws M 3 x 5
1 soldering lug
1 ceramic capacitor C 206; 1000 pf
1 deposited-carbon resistor R 124; 80 Ω 0.1 w
1 deposited-carbon resistor R 125; 125 Ω 0.1 w.

W. Strößenreuther

R&S Communications Equipment

The comprehensive R&S production line of measuring instruments and communications equipment, a survey of which is given in the September copy and in this issue, will be alternately discussed in detail in future editions of the "Kurzinformation".

A. Transmitters and Transmitter Systems

The type designation of the transmitters consists of 2 letters. The subsequent figures give the power rating of the transmitter in kilowatts (e. g., 08 for 800 w). The figures behind the solidus indicate the model.

1 Short-wave Transmitters (SK . . ./. . .)

Several transmitters with a power output of 100, 500, 800 w, 10 and 35 kw are available in the short-wave range of 1.5 to 24 Mc. The transmitters up to 800 w are suitable for mobile operation. Unlike the conventional practice of generating the frequency by means of exchangeable crystals (involving the costly provision of these crystals) or variable-frequency oscillators with a poor setting accuracy and insufficient frequency stability, a synthesizer produces the desired frequencies from one frequency derived from a carefully selected high-grade crystal.

Calibrated scales permit **frequency selection** without any auxiliary tables. Switches permit adjustment of the 1-Mc, 100-kc and 10-kc steps. Continuous adjustment is possible over the range 0 to 10 kc with an accuracy of ±5 cps, or ±50 cps in the case of the 100- and 500-w transmitters. This permits departure from the rated frequency by small amounts, which is important when there is an interference at this frequency. In general, the frequency variations within 24 hours are less than 1 part in 10^7 ±5 cps. The 35-kw transmitters are exclusively designed for remote frequency selection.

The **freqency setting accuracy** of all transmitters is so high that if a receiver of equal accuracy, e. g., the R&S Type EK 07, is used at the receiving station, a frequency change requires only the frequency scales to be set at both stations and the amplifier circuits of the transmitter to be tuned. The communication can then be established at once without any tuning against a beat note, an advantage which is particularly obvious in teleprinter service.

In the development, special importance was attached to obtaining versatility of the transmitter. Thus all commonly used **types of modulation** can be selected on the keying and modulation facilities provided. All transmitters can be laid out for single-sideband modulation. The types of modulation are as follows:

A1 = telegraphy on pure continuous waves
A2 = telegraphy modulated at audio frequency
A3 = telephony, AM
A3a = single-sideband telephony with reduced carrier
A3b = single-sideband telephony with reduced carrier and two independent sidebands
A4 = facsimile, AM
F1 = frequency-shift keying, 1 channel
F2 = telegraphy modulated at audio frequency, FM
F3 = telephony, FM
F4 = facsimile, FM
F6 = frequency-shift keying, 2 channels duoplex
A3 + F1 = telephony and frequency-shift keying, 1 channel, simultaneous
A3 + F6 = telephony and frequency-shift keying, 2 channels, simultaneous.

The transmitters are designed for **remote switching** and **remote keying.** Using a special remote-control unit they can be operated via post-office lines. 2 pairs of wires will be sufficient to perform the necessary switching, to provide for service calls and to ensure aural monitoring of the modulation.

Assembling the transmitters requires no soldering but merely a few plug-and-socket and clamping connections (power supply, microphone and keying circuits, earth and antenna). Since the transmitters are composed of individual units, a slide-in unit can readily be replaced, if necessary. Inside the slide-in units, the component parts are arranged in self-contained sub-assemblies.

2 VHF Broadcast Transmitters (SU . . ./. . .)

FM broadcast transmitters with an output power of 30, 250, 600 w and 3, 5, 10 kw are built for the frequency range from 87 to 108 Mc. All stages including the exciters can be continuously adjusted over the entire frequency range. The transmitter is crystal-stabilized during operation.

The transmitters are designed for parallel and standby operation. In standby operation, a standby transmitter is automatically connected to the antenna in case of transmitter outage. Parallel operation requires a double transmitter system, e. g., 2 x 3 kw, which operates into a common antenna. If one of the transmitters is not operating the second transmitter will continue to feed one half of the original power to the antenna. Remote switching and remote control of the transmitters permit the operation of unattended stations.

3 **Frequency-converter Type Transmitters** (UU . . ./. . .)

For use in VHF broadcasting, the frequency-converter type transmitters are comprised of a receiving unit, a converter unit and a 10-w or 250-w output amplifier. More power can be obtained using additionally normal VHF transmitter amplifiers. Parallel and standby operations are possible.

Two TV converter type transmitters are available with an output power of 0.5 w and 100 w. These converters consist of a receiving section, IF section, sync pulse restorer and an RF unit.

4 **UHF TV Transmitters** (SD 2/. . .; SD 10/. . .)

The 2-kw tetrode transmitter and the 10-kw klystron transmitter are designed for operation in Band IV and Band V. The input stages are continuously adjustable over both bands; continuous adjustment of the output stage is possible only within one band.

5 **ATC Transmitters** (SU 007/. . .; SD 002/. . .)

An amplitude-modulated air-traffic-control transmitter provides for ground-to-air radio communication in ground stations in the frequency range 100 to 156 Mc. The maximum output power switch-selected in 3 steps is 105 w or, using a final amplifier, 10 kw. The exciter is equipped with plug-in crystals. Another ATC transmitter operates in the frequency range 225 to 450 Mc with an output power of 20 w or, using a transmitter power stage, 1 kw. The channel changeover is accomplished by means of plug-in crystals or a ten-channel oscillator which makes for ease of operation. Both transmitters are suitable for remote-control operation.

6 **Transmitter Monitors and Accessories**

Power meters, modulation measuring instruments, deviation meters, picture transmitter monitors, sound and picture transmitter test assemblies are available for transmitter monitoring.

Antenna filters and transmitter combining filters including VHF and UHF TV diplexers permit simultaneous operation of several transmitters into a common antenna and isolation between parallel-connected transmitters operating on different frequencies with a power output up to 10 kw. The R&S production line includes also load resistors for 50 w to 16 kw and 0 to 3000 Mc, impedance transformers, etc., changeover equipment for RF transmission lines, remote-control units, and so forth.

B. Antennae (HA . . ./. . .)

1 **Short-wave Antennae**

In the short-wave range, ROHDE & SCHWARZ offer a number of cage antennae (HA 47/. . .) with a power-handling capacity up to 20 kw for use as vertically-polarized, omnidirectional antennae in the frequency range from 1.5 to 28 Mc. Cage antennae are also available for mobile operation. In conjunction with suitable reflector sheets (Corner Reflector Antennae Type HA 147/. . .) these broadband cage antennae have special directional characteristics. For use as receiving antennae, ROHDE & SCHWARZ supply the log periodic antennae (HA 226/. . .) covering a very wide band.

2 **VHF and UHF Antennae for Broadcast Operation**

For FM broadcast transmitters in Band II, turnstile and cylindrical antennae with a power-handling capacity up to 30 kw are employed as omnidirectional antennae. Horizontally-polarized tubular dipoles with reflector dipoles may be combined to form antennae with any desired radiation pattern. Omnidirectional super-turnstile antennae (HA 44/. . . and HA 88/. . .) with a power-handling capacity up to 10 kw are available for radiation in the TV Bands I and III. This type of antenna offers the advantage of easy isolation between the sound and the picture transmitter. Instead of the TV diplexers the simple diplexers may be used. The directional arrays consisting of collinear dipole arrangements with reflector sheets which were designed for all bands from I to V may be combined to form antennae with any desired horizontal or vertical radiation pattern. Where necessary, the directional arrays may also be laid out for vertical polarization. The VHF relay receiving antennae covering the Bands I, II and III (HA 9/. . .) feature a very stable input impedance.

3 **Antennae for Air Traffic Control and for Fixed and Mobile Radio Services**

The VHF and UHF air traffic control stations and transmitting stations for fixed and mobile radio service use primarily vertical polarization. For this purpose, omnidirectional antennae covering a very wide band are supplied with a power-handling capacity up to 10 kw. The coaxial dipoles are of particularly simple design. They can handle a power of 200 to 1500 w. Direction-finding antennae are listed under air traffic control receiving systems.

4 Antennae for Radio Monitoring, Test Antennae, Auxiliary Units

VHF and UHF measuring and monitoring receivers as, for instance, used in propagation investigations, radio monitoring or interference measurements, call for antennae which cover large portions of the entire VHF and UHF range. This is accomplished by broadband antennae whose input impedance and directional characteristic ensure optimum reception of incoming signals. Numerous types of horizontally and vertically polarized cone antennae (HA 73/...; HA 74/...), corner reflector antennae (HA 119/...; HA 172/...), log periodic antennae (HA 226/...), Yagi antennae (HA 46/...; HA 246/...) and turnstile antennae (HA 56/...; HA 256/...) with adjustable elements were therefore developed for the frequency range from 30 to 1000 Mc. Remote-controlled rotary masts for directional antennae (HA 55/...) and remote-controlled adjustable dipole-reflector arrangements are used to advantage for propagation investigations, field-strength measurements and radio monitoring. Parabolic antennae (HA 262/...) extend the frequency range to 2.7 Gc.

C. Receivers and Receiving Systems

1 Short-wave Receivers

The Short-Wave Receiver Type EK 07 (0.5 to 30.1 Mc) is excellent as a communication and monitoring receiver, even under adverse conditions in mobile and fixed radio stations. It is particularly useful also in large stations, in monitoring of assigned frequency bands and in commercial telegraphy as well as telephony. The Type EK 07 features the exceptional setting accuracy of better than 1 kc, high selectivity and image rejection with three tuned input circuits and a noise figure of better than 10 db. Not only amplitude-modulated stations radiating A1 to A4 signals will be received, but, in conjunction with auxiliary units, also F1 to F4 and F6 modulated signals as well as single-sideband transmissions of the types A3a and A3b. These auxiliary units provide, at the same time, the changeover facilities for

dual or triple diversity antenna selection,
dual diversity or
dual diversity frequency selection.

They permit direct connection of telegraphy equipment, such as teleprinters, recorders, Hellfax equipment, etc., without a separate DC power supply and, in the case of double-channel transmissions, simultaneous operation in each of the two communication channels. The receiver Type EK 07 can also be remote controlled from a far-away point. A noteworthy receiver is also the Field-Strength Meter Type HFH (0.1 to 30 Mc). Multicouplers are available for large receiving systems comprising many receivers and improve the effectiveness of an antenna system by allowing multiple use of it.

2 Receivers for Radio and Carrier-frequency Operation

The high-quality commercial FM Receiver Type ESB has proved valuable in the VHF range. It is marketed in a number of different versions, namely as
relay receiver for radio operation,
TV sound relay receiver,
long-distance receiver for CF systems or transmission of radio programmes over wide areas,
short-distance receiver for CF or radio relay links.

The Television Relay Receiver Type EU 038 serves for the relay reception of television transmissions. VHF receiving systems for VHF radio and directional radio transmissions have been designed for fixed communication over radio networks and FM multi-channel radio links. These systems consist of one or more VHF receiving antennae, multicouplers and any desired combination of receivers of the Type ESB series. If the receiving systems are to be used for the modulation of transmitter signals or as radio link terminals two receivers may be connected via an automatic switchover apparatus to enhance the safety of operation.

3 Air Traffic Control Systems

The two **receivers** Type NE 1/2 (100 to 156 Mc) and Type ED 80 (225 to 400 Mc) are foremost used in fixed and mobile ground stations for aeronautical communication (ground-to-air radiotelephony). They are of the double superheterodyne type containing crystal-controlled oscillators for the reception of a fixed frequency. The frequency is changed by exchanging the crystals and single-knob tuning of the RF circuits. The 10-Channel Oscillator Type ED 20 generates the ten selectable frequencies and considerably facilitates the channel selection of the Type ED 80. The receivers may be combined into receiving systems which permit the simultaneous reception of several channels.

The **Wide-Aperture Visual Direction Finders** Type NP 4 also deserve mention here. They provide automatic direct indication of the azimuth of VHF transmitters in the frequency range from 100 to 156 Mc, especially for air traffic control and radio monitoring even if the terrain is very unfavourable. An illuminated pointer gives unambiguous azimuth indication on an illuminated scale 15 cm in diameter. Indication of the bearing is possible at the DF station or on slave indicators up to 10 miles away.

Addition of accessory units permits the equipment to be employed for displaying the bearing on ASR screens and, using bearing transmission equipment, for combining remote direction finders for position finding. Fixed and mobile systems available in various models to suit all requirements include up to 9 receiving channels. A similar system has been developed for the UHF range.

4 Radio Monitoring Equipment

The VHF Receiver Type ESG is used as a communication and monitoring receiver for the frequency range from 30 to 330 Mc. It permits reception of the various radio services, such as FM broadcasting, fixed and mobile radio services using narrow-band frequency modulation, FM relay radio service for CF telephony, and aeronautical radio service employing amplitude modulation. For this purpose, the Type ESG features an adjustable squelch circuit, a noise limiter, and a beat-frequency oscillator for operation on keyed continuous waves. With certain restrictions because of the maximum IF bandwidth of 300 kc, the receiver lends itself also to the monitoring of television and pulse-modulated transmitters.

In addition, the set has all facilities and properties for the direct measurement of frequencies, of the field strength (in conjunction with an antenna and a calibration oscillator), of the frequency swing, and of the modulation depth. Furthermore, it can be used as a laboratory microvoltmeter. Electronic stabilization of all operating voltages ensures that the frequency accuracy and gain remain constant even with AC supply voltages varying as much as ±10%. Thus accurate measurements and recordings over long periods of time are possible. Special calibration circuits permit continuous monitoring of the essential characteristics of the receiver and their correction.

The VHF Monitoring Receivers Types ESM 180 and ESM 300 find application in the frequency range from 30 to 180 Mc and 85 to 300 Mc. They serve for receiving both amplitude- and frequency-modulated emissions. An output for connection of an oscilloscope permits displaying pulse-modulated waves and interfering frequencies. In conjunction with a calibration oscillator the receivers can be used for the measurement of field strength since the input voltage is indicated by a meter.

A considerable extension of the frequency band towards higher values is possible using the VHF-UHF Receiver Type ESU. Its three RF plug-in units cover together a frequency range of 25 to 900 Mc. The receiver is designed for AM and FM demodulation. It contains a beat-frequency oscillator, switch-selected automatic frequency control and a bandwidth selector. The locking standardizing oscillator of the Type ESU and the linear and logarithmic field-strength indication as well as the necessary IF outputs permit field-strength measurements.

Two small and handy field-strength indicators are available in the freqency ranges 47 to 225 Mc and 430 to 610 Mc.

Spa.

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